Water Requirements for the Fisheries Resource of the Englishman River, Vancouver Island, B.C.

Roy E. Hamilton and G.T. Kosakoski

Department of Fisheries and Oceans
1090 West Pender Street
Vancouver, B.C. V6E 2P1

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WATER REQUIREMENTS FOR THE FISHERIES RESOURCE OF THE ENGLISHMAN RIVER VANCOUVER ISLAND, B.C.

by

Roy E. Hamilton

G.T. Kosakoski[1]

Department of Fisheries and Oceans
1090 West Pender Street
Vancouver, B.C.

[1]Department of Fisheries and Oceans
60 Front Sreet
Nanaimo, B.C.

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ABSTRACT

HAMILTON, ROY, E. and KOSAKOSKI, G.T., 1982. "Water Requirements for the Fisheries Resource of the Englishman River, Vancouver Island, B.C." Can. MS Rep. Fish. Aquat. Sci. 1676: vii + 42p.

The hydrology of the Englishman River is examined and low flows analysed. The most critical low flow period is between August 10 and September 20 when it is most probably that river flow will drop below 25 cfs. Data is provided on distribution, timing, and escapement of the several Pacific Salmon species. A biophysical inventory is included. Spawning and rearing habitat was studied in detail. Useable habitat versus discharge curves were prepared and rearing populations were estimated. Recommendations for Fisheries Resource Maintenance Flows are 40 cfs for rearing and 200 to 300 cfs for spawning. It is recommended that a minimum of 500 acre feet of storage be provided to support the water diversion licence applied for by the town of Parksville and that it be released to fully support the diversion when the river flow drops below 25 cfs.

Key Words: Hydrology, Pacific Salmon, Low Flows, Water Diversion, Fisheries Flows

RESUME

HAMILTON, ROY, E. and KOSAKOSKI, G.T., 1982. Water Requirements for the Fisheries Resource of the Englishman River, Vancouver Island, B.C." Can. MS Rep. Fish. Aquat. Sci. 1676: vii + 42p.

Le présent rapport porte sur l'hydrologie de la rivière Englishman et sur ses faibles débits. La période la plus critique pour les faibles débits dure du 10 août au 20 septembre, quand le débit de la rivière est très susceptible de baisser au-dessous de 25 pcs. Voici les données présentées au sujet des différentes espèces de salmonidés du Pacifique: répartition, particularités chronologiques et remontées; il y a aussi un inventaire biophysique. Les frayères et les aires de croissance sont étudiées en détail. Des courbes de l'habitat utilisable en fonction du débit ont été tracées et les populations reproductrices évaluées. On recommande de maintenir le débit à 40 pcs pour la croissance et à 200 à 300 pcs pour la fraye, dans le cadre du programme de débits pour la préservation des ressources halieutiques. On propose également de fournir un réservoir de 500 acres-pieds, afin d'obtentir un permis de dérivation des eaux demandé par la ville de Parksville, réservoir qu'il faudrait vider si le débit baissait à moins de 25 pcs.

Mots-clés: hydrologie, saumon du Pacifique, faibles débits, dérivation des eaux, débits pour la préservation des ressources halieutiques.

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1. INTRODUCTION

The Englishman River drains a watershed area of approximately 336 km^2, and flows in a generally northerly direction into Georgia Strait at Parksville, on the east coast of Vancouver Island (Figure 1). It is an important salmon and trout stream, located in an area of rapid residential and commercial growth. As is typical of many streams in the area, very low flows often occur in late summer and early fall, with peak flows normally occurring in winter, reflecting the seasonal distribution of precipitation.

In 1979, the Town of Parksville applied for a water licence to divert 1,510,000 gallons per day from the lower Englishman River which, in addition to their existing water licences for 1,200,000 gpd, represents a total potential diversion of 2,710,000 gpd or 5.0 cfs. The minimum daily discharge recorded over the period of record for the Englishman River is 3.0 cfs on September 4, 1914. Flows as low as 6.0 cfs have been recorded as recently as September 1, 1970. Depending on the location of the intake, (i.e. at the present facility located approximately 1.5 km from the mouth, or at a new site upstream) up to 3 km of fish habitat in the lower Englishman River could be seriously affected during low flow periods by the proposed diversion.

ENGLISHMAN RIVER FALLS PARK

ENGLISHMAN RIVER FALLS

ENGLISHMAN RIVER

MORISON CREEK

TRIBUTARY

SOUTH ENGLISHMAN RIVER

POWER LINE R/W

E&N

center of air photo

006

080

081

082

083

172

173

180

187

188

189

"G"

1

2

3

4

5

6

7

LEGEND

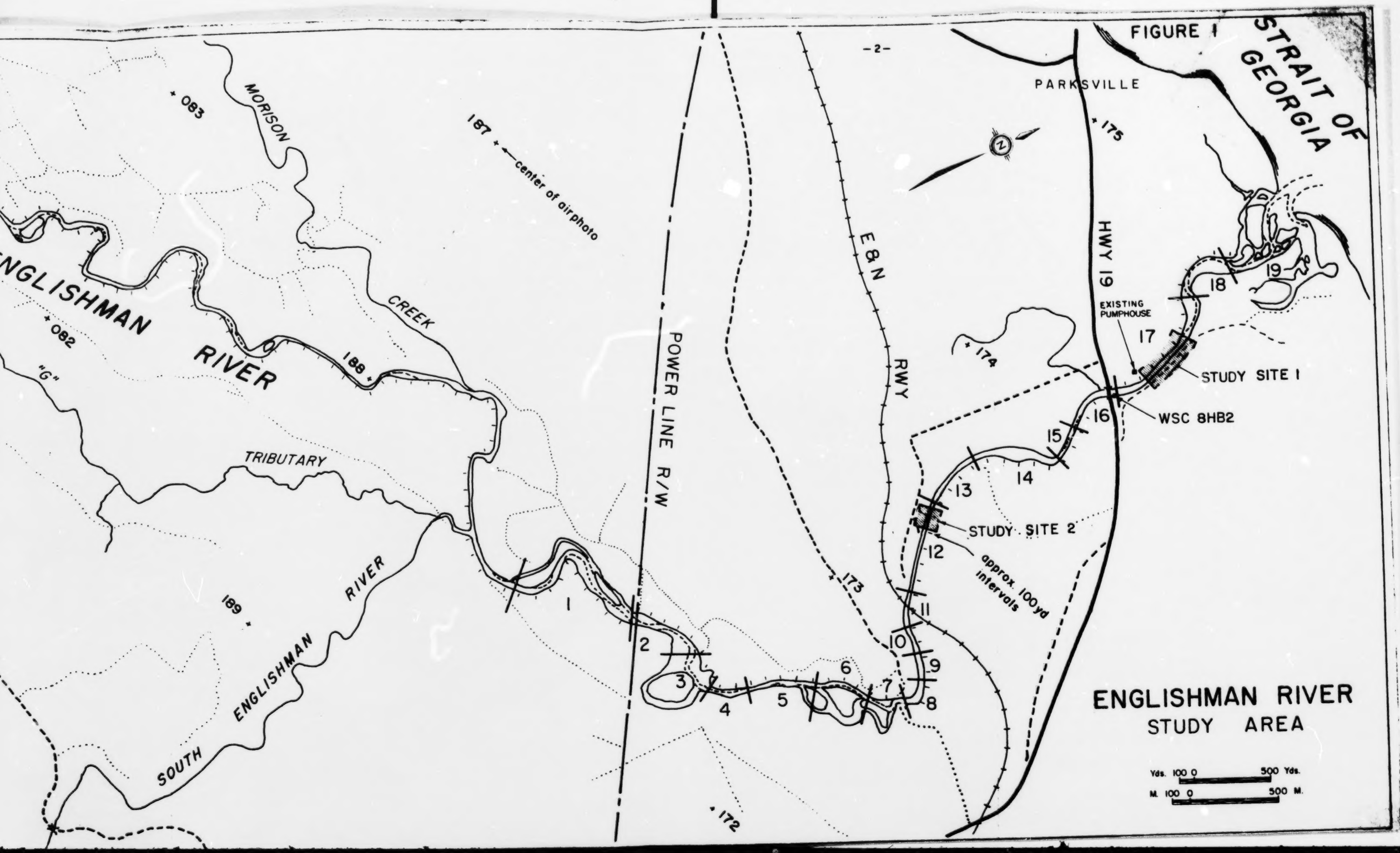
15 – REACH BOUNDARIES

– SECONDARY ROAD

– LOGGING ROAD / TRAIL

FIGURE 1

ENGLISHMAN RIVER
STUDY AREA



As a result of this concern, biological and engineering studies were initiated in the summer of 1979 by the Habitat Management Division to determine instream flow requirements for salmon in the lower Englishman River and to provide the technical basis for recommendations to the Water Management Branch of the B.C. Ministry of Environment concerning the new water licence application.

2. FISHERIES RESOURCE

The Englishman River system is an important producer of chum (Oncorhynchus keta) and coho salmon (O. kisutch). Populations of chinook (O. tshawytscha), sockeye (O. nerka) and pink salmon (O. gorbuscha), as well as steelhead (Salmo gairdneri) and cutthroat trout (S. clarki), also occur.

Ten year average escapements for the period 1971-80 (with maximum recorded escapements in brackets) are chum, 4,475 (35,000); coho 845 (3,500); chinook, 53 (115); pink, 36 (3,500); and sockeye, 63 (300). Annual escapement data for chum and coho are given Figure 2.

Englishman River stocks contribute to the commercial fishery, the Georgia Strait sport fishery and, to some extent, the native food

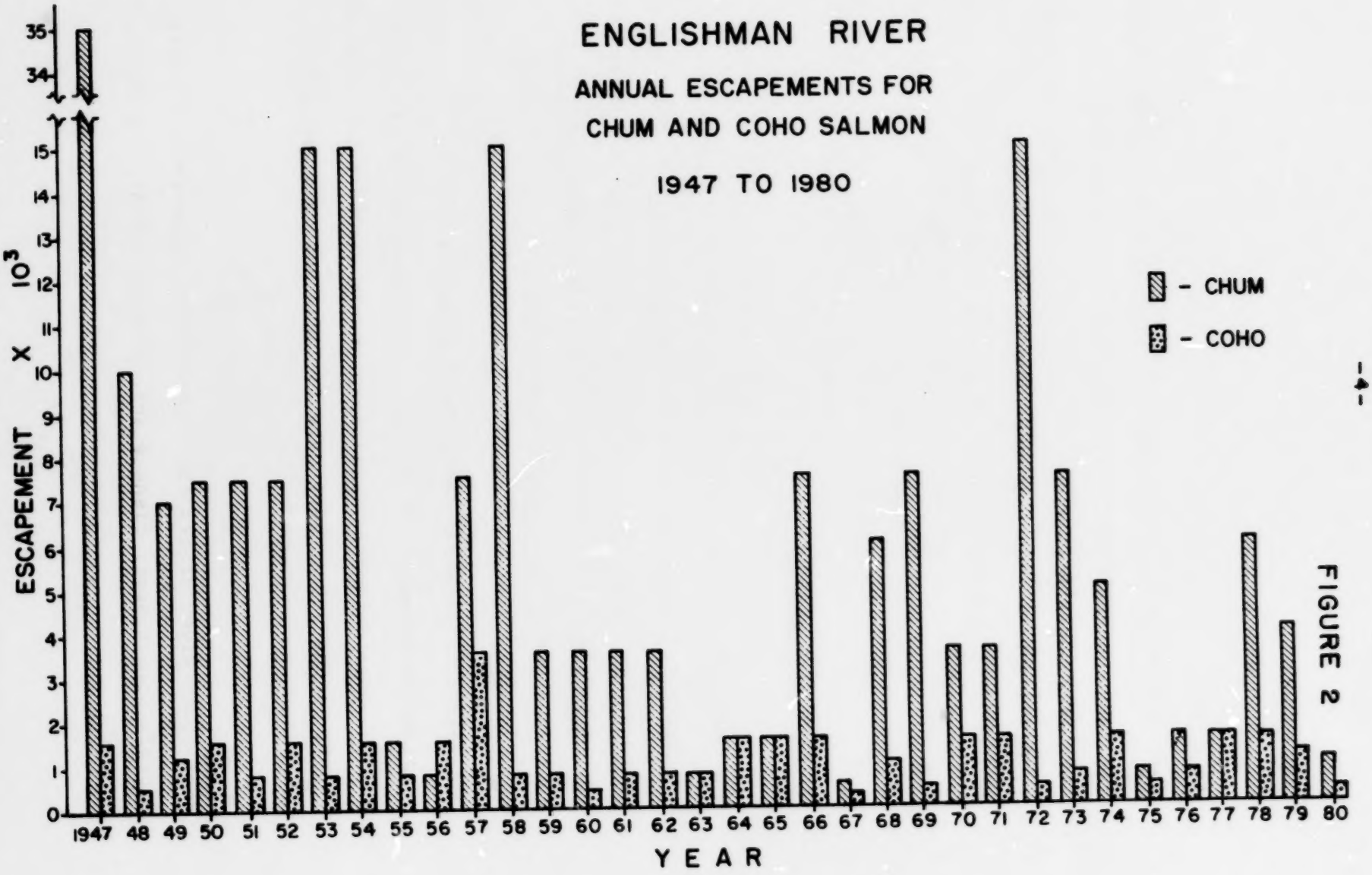

ENGLISHMAN RIVER
ANNUAL ESCAPEMENTS FOR
CHUM AND COHO SALMON
1947 TO 1980
ESCAPEMENT X 10^3
- CHUM
- COHO
YEAR
1947 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

FIGURE 2

fishery. In addition, the Englishman River is one of the more important steelhead angling streams on the east coast of Vancouver Island, with an estimated total catch (kept plus released) of 382 in 80-81 (Ford 1982).

2.1. SPAWNING DISTRIBUTION

The Englishman River mainstem is accessible to anadromous salmonids for approximately 16 km, at which point further migration is prevented by a series of impassable falls (Figure 3). Accessible tributaries include Morison Creek and the South Englishman River.

The spawning distribution for each species as shown in figure 2 is based largely on annual stream and spawning ground reports, but additional information was obtained from a series of snorkel surveys, supported by the Salmonid Enhancement Program, which were conducted by two local residents from August, 1978 to March, 1979.

Chum

Spawning occurs mainly in the lower 6.5 km of the mainstem. Fraser et. al (1974), however, have estimated that sufficient

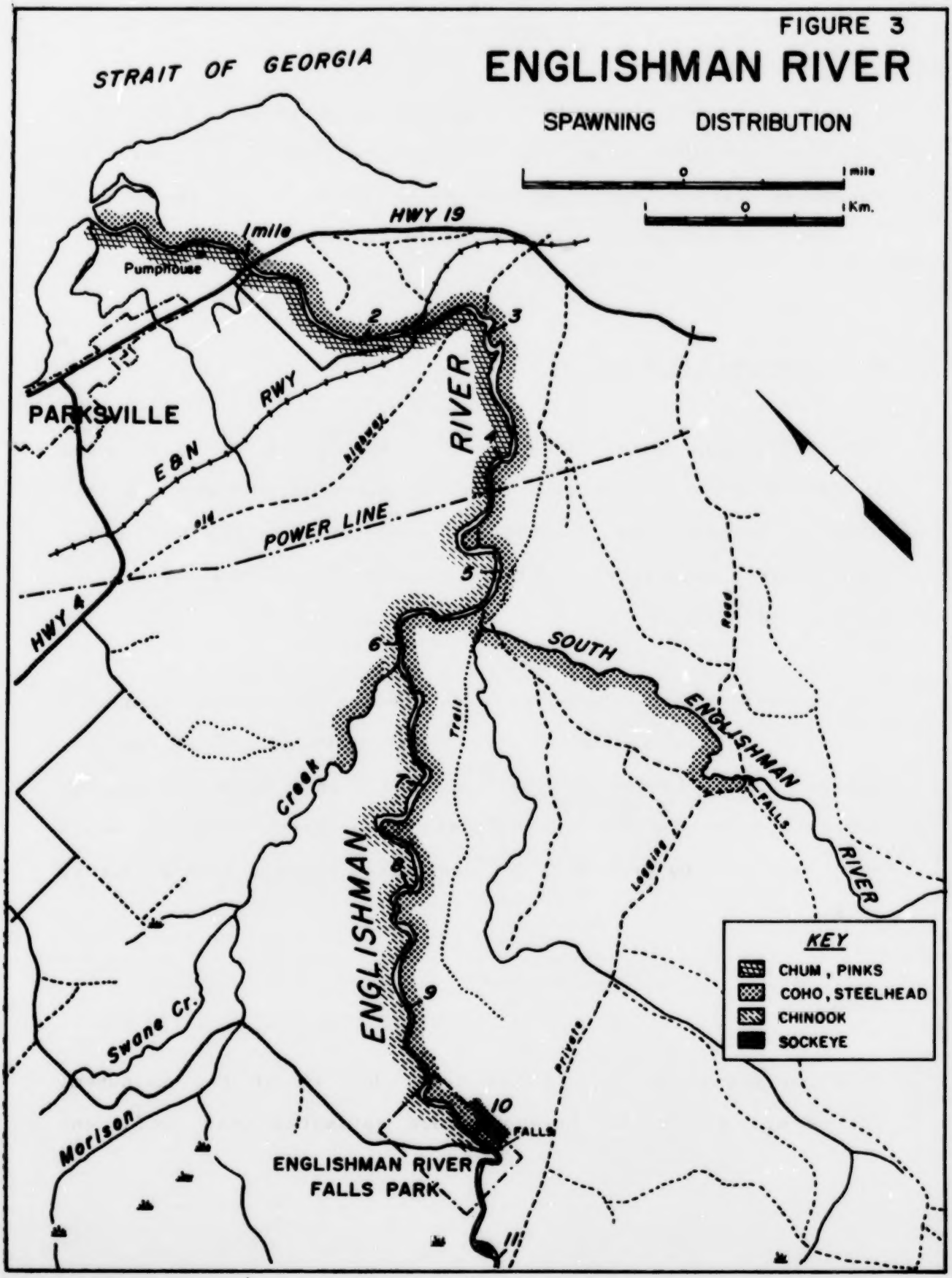


FIGURE 3
ENGLISHMAN RIVER
SPAWNING DISTRIBUTION
STRAIT OF GEORGIA
0 1 mile
0 1 Km.
HWY 19
1 mile
Pumphouse
2
3
PARKSVILLE
RWY
E & N
Highway
RIVER
POWER LINE
old
HWY 4
5
6
SOUTH
ENGLISHMAN
RIVER
Road
Trail
Creek
ENGLISHMAN
FALLS
Logging
Swane Cr.
9
Private
Morison
10
FALLS
ENGLISHMAN RIVER
FALLS PARK
11
KEY
CHUM, PINKS
COHO, STEELHEAD
CHINOOK
SOCKEYE

potentially usable spawning area exists upstream of this area for approximately 4,000 additional spawners.

Coho

Although spawning occurs throughout the system, the 3 km reach downstream of the confluence of Morison Creek appears to be an important holding and spawning area. The extent of utilization of the South Englishman River and Morison Creek is not known, although fry were observed in both tributaries. Walker and MacLeod (1970) reported that suitable spawning and rearing habitat exists for 13 km above the Englishman River Falls, representing an estimated production potential of 5,600 coho.

Pink

Historically, pink salmon utilized the lower reaches of the mainstem for spawning. However, the population, which was generally stronger on even-numbered years, has been reduced to less than 5% of its former abundance.

The virtual extinction of this stock is a phenomenon common to many small pink populations in the area, and can be attributed to a combination of over-exploitation of weaker stocks by the fishery, and reduced freshwater survival associated with a general deterioration of spawning and incubation habitat.

Chinook

Scattered spawning occurs in the middle and upper reaches.

Sockeye

Distribution of this species appears to be limited to the upper river in the vicinity of the lower falls.

2.2 TIMING

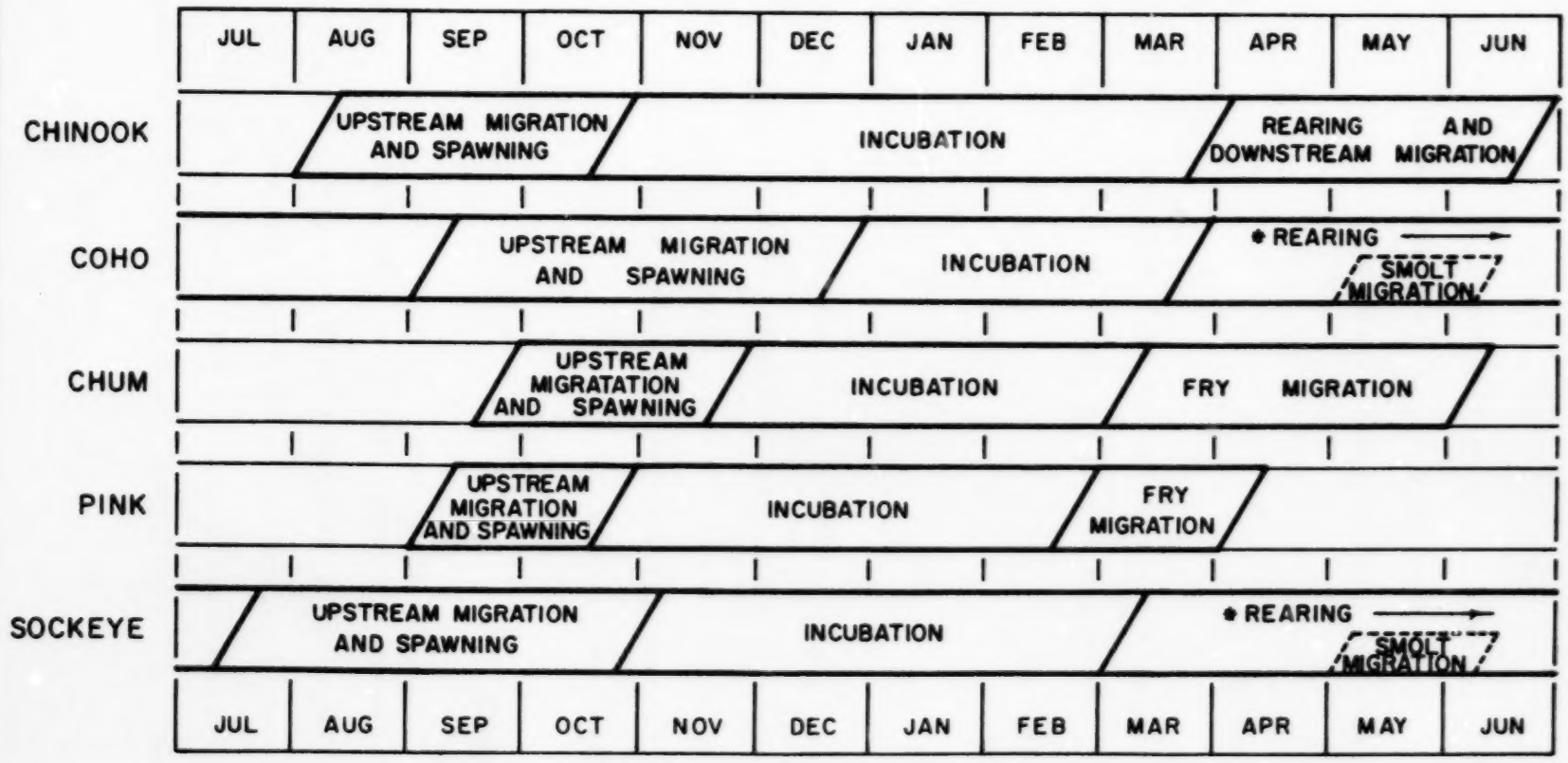
Freshwater life histories of Englishman River salmon stocks have not been thoroughly documented. However, based on escapement records, juvenile sampling, and limited scale data, the following estimates of the timing of the various freshwater phases for each species have been made (Figure 4).

Chum

Chum first appear in the system during the latter part of September or early October, with the peak of spawning generally occurring in late October or early November. After emerging from the gravel in March or April, chum fry emigrate almost immediately to

ENGLISHMAN RIVER

FRESHWATER TIMING FOR ENGLISHMAN RIVER SALMON



* YEAR ROUND REARING.

FIGURE 4

the estuary. A juvenile sampling program conducted in the Englishman River estuary in 1979 indicated peak numbers of chum migrants in April and May (Tutty et al 1979).

Pink

Adults arrive and spawn in late September or early October. Fry emerge from the gravel in March or April and migrate immediately to salt water.

Coho

Upstream migration normally begins in early September. Spawning activity peaks in mid-November and continues into January. After emerging in April or May, coho fry rear in the system for one year (sometimes two years) before migrating to the sea as smolts the following May or June.

Chinook

Escapement records indicate that chinook normally enter the system in late September with the peak of spawning occurring in October. During snorkel surveys conducted in the summer and fall of 1978, however, chinook were observed in the river as early as August 6, with peak numbers observed in the latter part of

September. Fry emerge in April and rear in the system for approximately 3 months.

Sockeye

Records variously report small numbers of "creek" sockeye arriving and spawning in July-August or in September-October. In 1978, sockeye were observed in the upper river in late October.

3. BIOPHYSICAL INVENTORY

In June, 1979, the lower 8 km of the Englishman River was divided into 19 reaches, in addition to those sections of Morison Creek and the South Englishman River utilized by anadromous salmonids. Reach boundaries are shown in Figure 1. The following information was recorded during the survey: wetted width, substrate composition, bank cover, occurrence of secondary channels, pool-riffle ratios, and juvenile salmonid distribution.

Biophysical inventory data for the lower 8 km of the Englishman River, as well as the South Englishman River and Morison Creek, is summarized in Appendix A. This section of the Englishman River is characterized by a mean gradient of 0.36% (Figure 5), and provides good spawning habitat in the lower 3 km, particularly for chum. In addition, much of the lower Englishman River

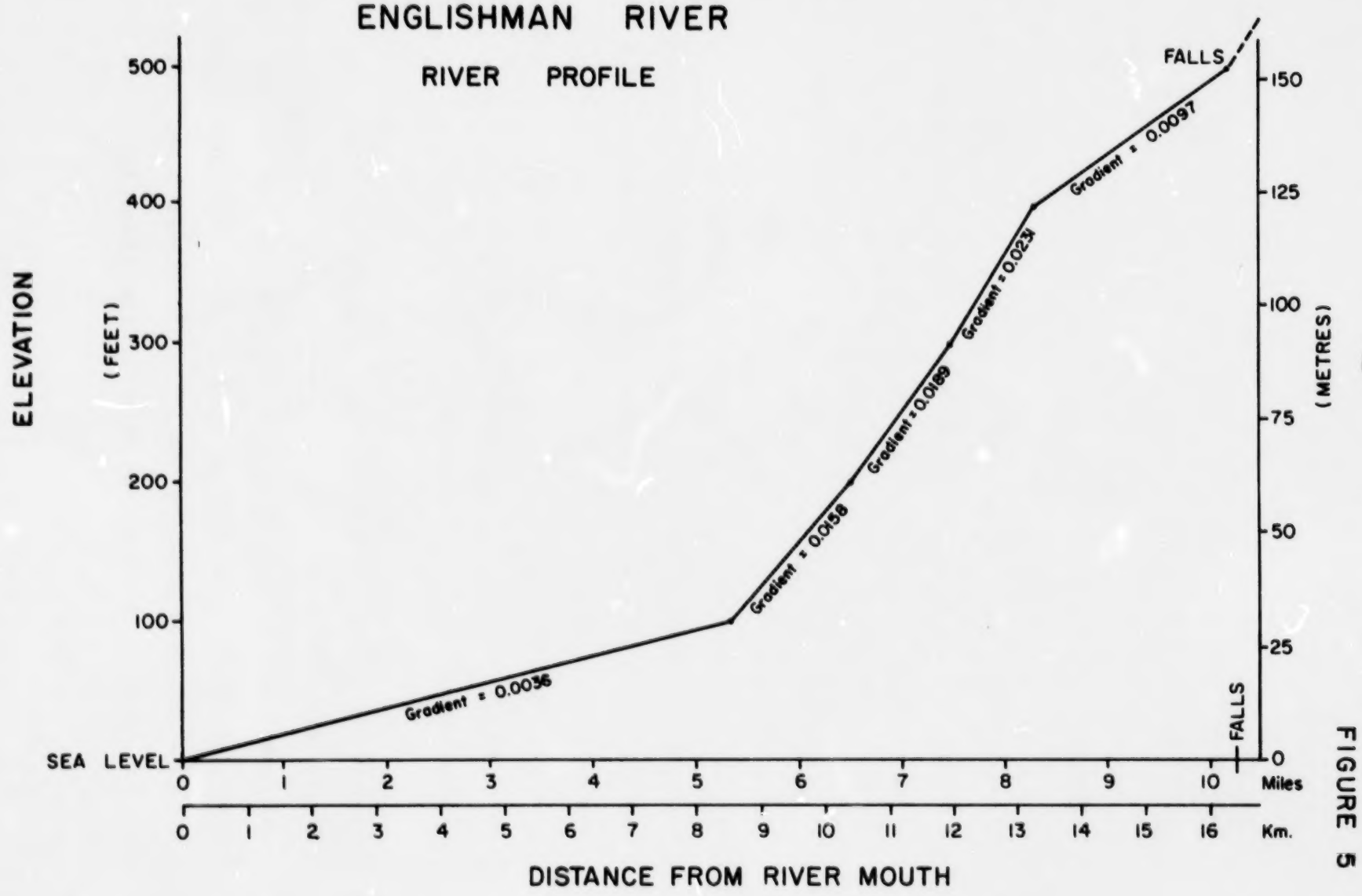

ENGLISHMAN RIVER
RIVER PROFILE
ELEVATION
(FEET)
500
400
300
200
100
SEA LEVEL
(METRES)
150
125
100
75
50
25
0
FALLS
Gradient = 0.0036
Gradient = 0.0158
Gradient = 0.0189
Gradient = 0.0231
Gradient = 0.0097
0 1 2 3 4 5 6 7 8 9 10 Miles
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Km.
DISTANCE FROM RIVER MOUTH

FIGURE 5

provides continous bank cover and excellent coho rearing habitat. Upstream, beyond 8.5 km., the average gradient increases significantly with a corresponding increase in average substrate size. Although this section was not surveyed in detail, observations indicate scattered areas of suitable spawning habitat for coho and chinook, and good rearing habitat for steelhead.

The lower reaches of the South Englishman River and its main tributary ("G" tributary) and Morison Creek were found to be utilized by both coho and trout fry.

4. HYDROLOGY AND STREAM FLOW ANALYSIS

The Englishman River watershed of 336 sq. km. rises to an elevation of some 5,000 feet at the divide. There are three small lakes in the upper watershed, two of them at an elevation of about 3,500 feet and one at an elevation of about 2,600 feet.

Morison Creek sub-basin represents 14% of the total watershed area and the South Englishman River 26%. The gradient of the mainstem up to Englishman Falls is shown in figure 5.

Average annual precipitation on the watershed is 45 inches, varying from 30 inches at sea level to 60 inches at the headwater lakes.

Air and water temperatures were measured with a recorder located at study site 2 for part of 1979 (Figure 6). Unfortunately, very little data were obtained for the hot weather period of July-August. It is evident, however, that high water temperatures in August combined with low flows could be a serious problem for juvenile salmonids.

Historical stream flow data are limited, with only 10 incomplete years of record to 1981. The hydrometric station 8HB002 was orignally established in 1913 about one half mile up from the river mouth. It was discontinued in 1917. Two more years of record were obtained in 1970-71 but it was again discontinued until 1979 when it was reestablished at the highway bridge about one mile from the mouth of the river. Average monthly flows are shown in Figure 7.

Partial daily hydrographs are shown in figures 8 and 9. The shaded areas represent periods when the flow has been less than 25 cfs. (This is a flow considered to be a minimum requirement for rearing, as discussed in a later section). It can be seen that these periods generally occur between August 10 and

FIGURE 6

ENGLISHMAN RIVER

AIR & WATER TEMPERATURES AND DISCHARGE FOR PART OF 1979

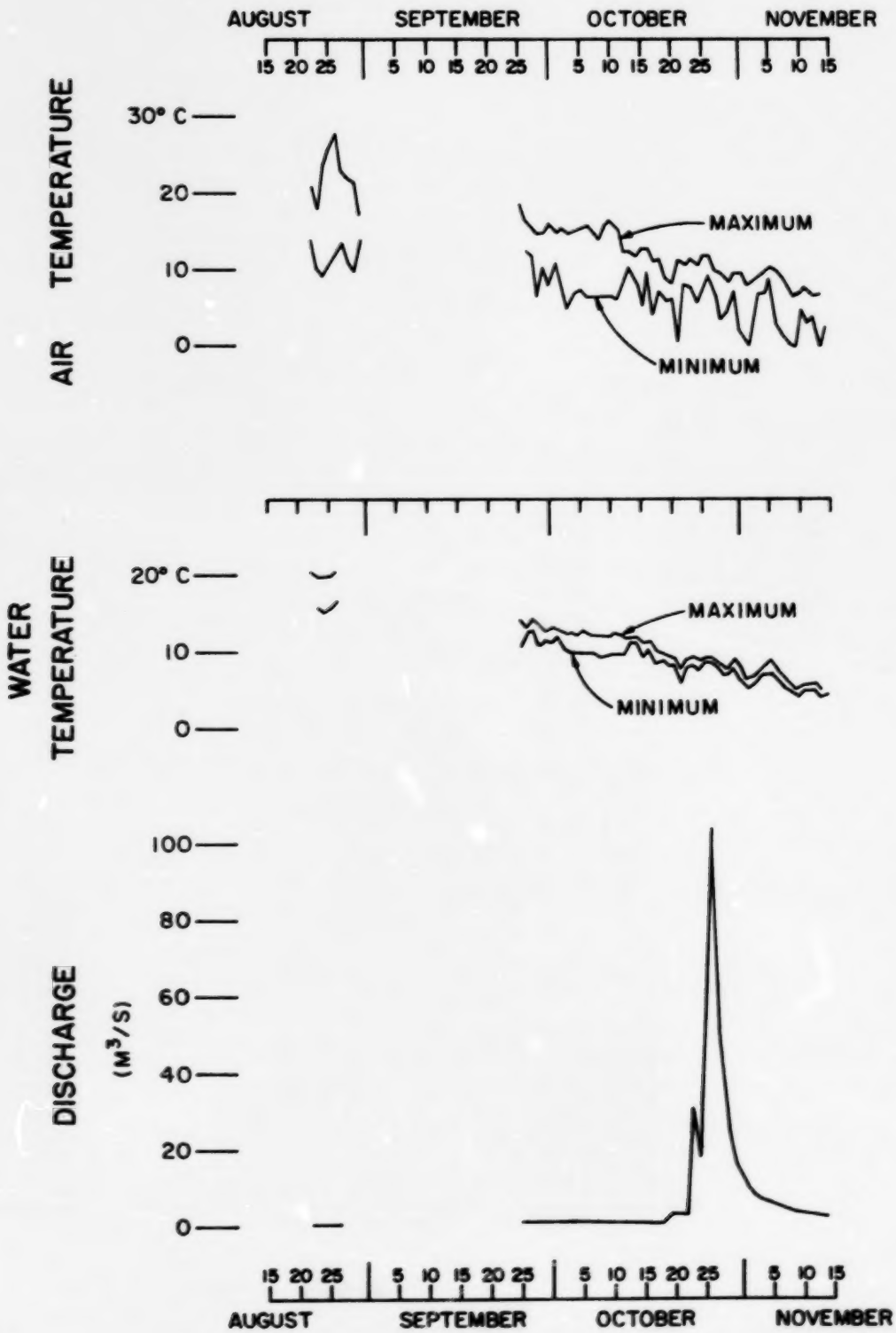
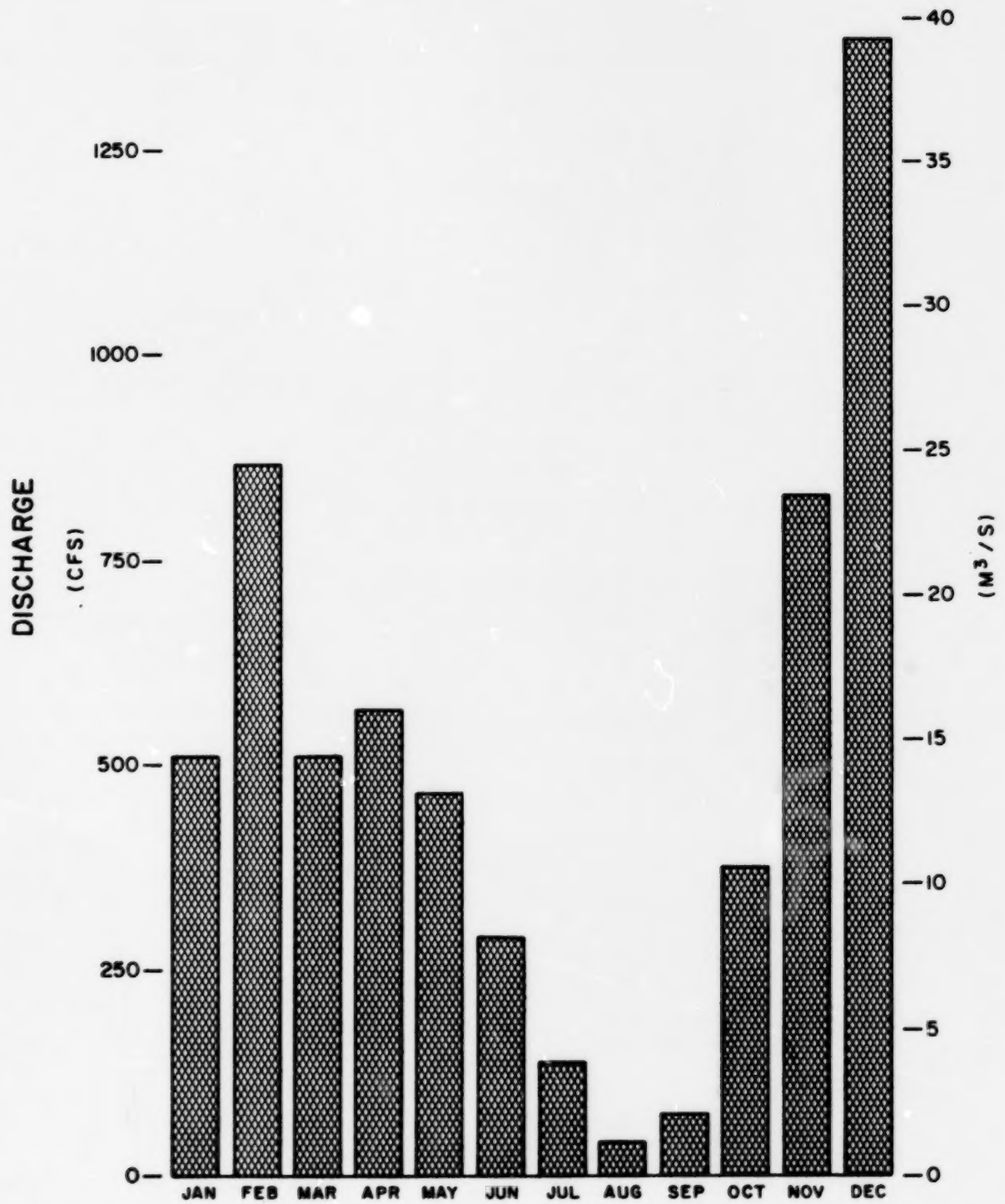


FIGURE 7

ENGLISHMAN RIVER

AVERAGE MONTHLY FLOWS

1913 - 1981



1913 - 1981

FIGURE 8

ENGLISHMAN RIVER

PARTIAL HYDROGRAPHS

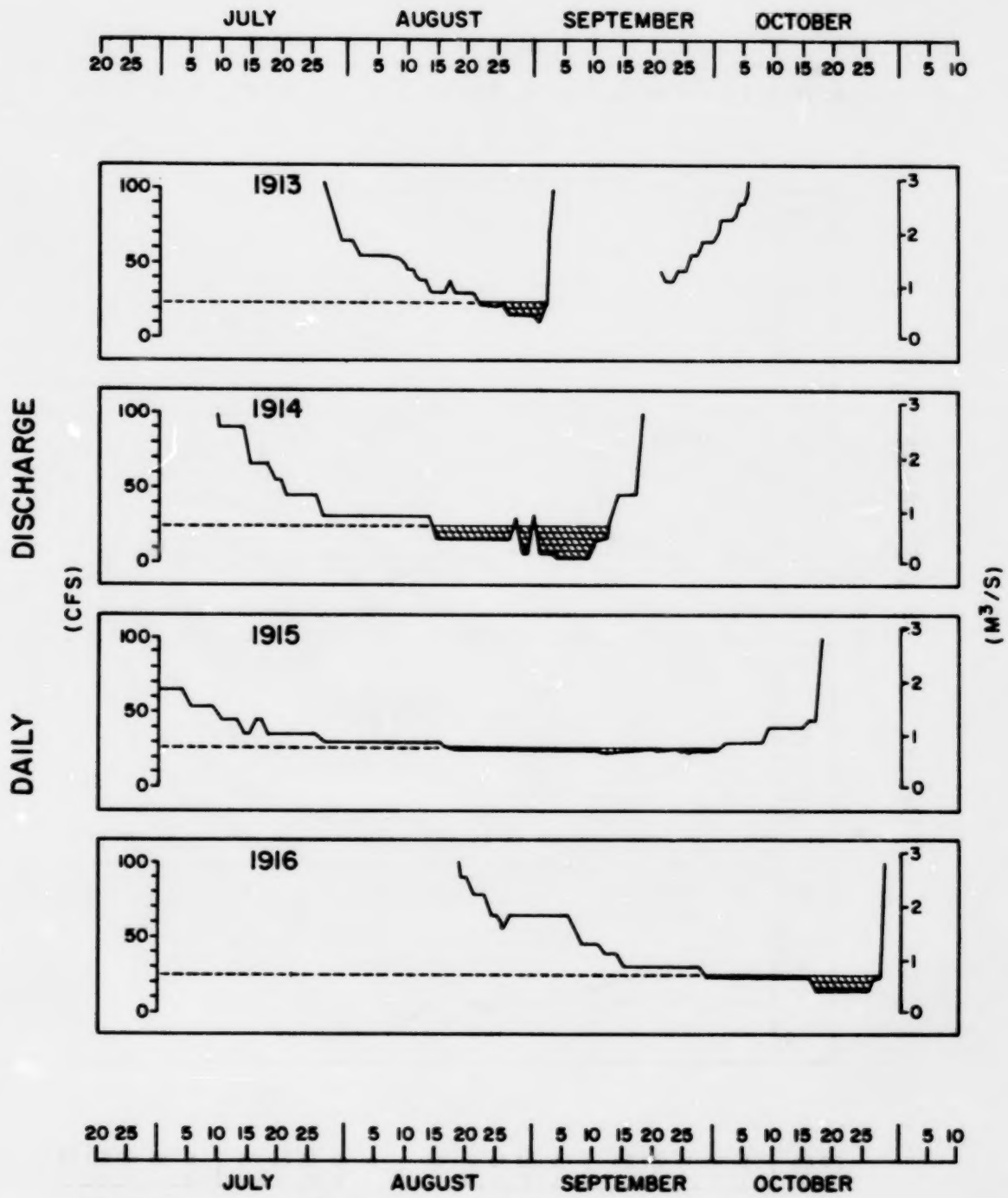
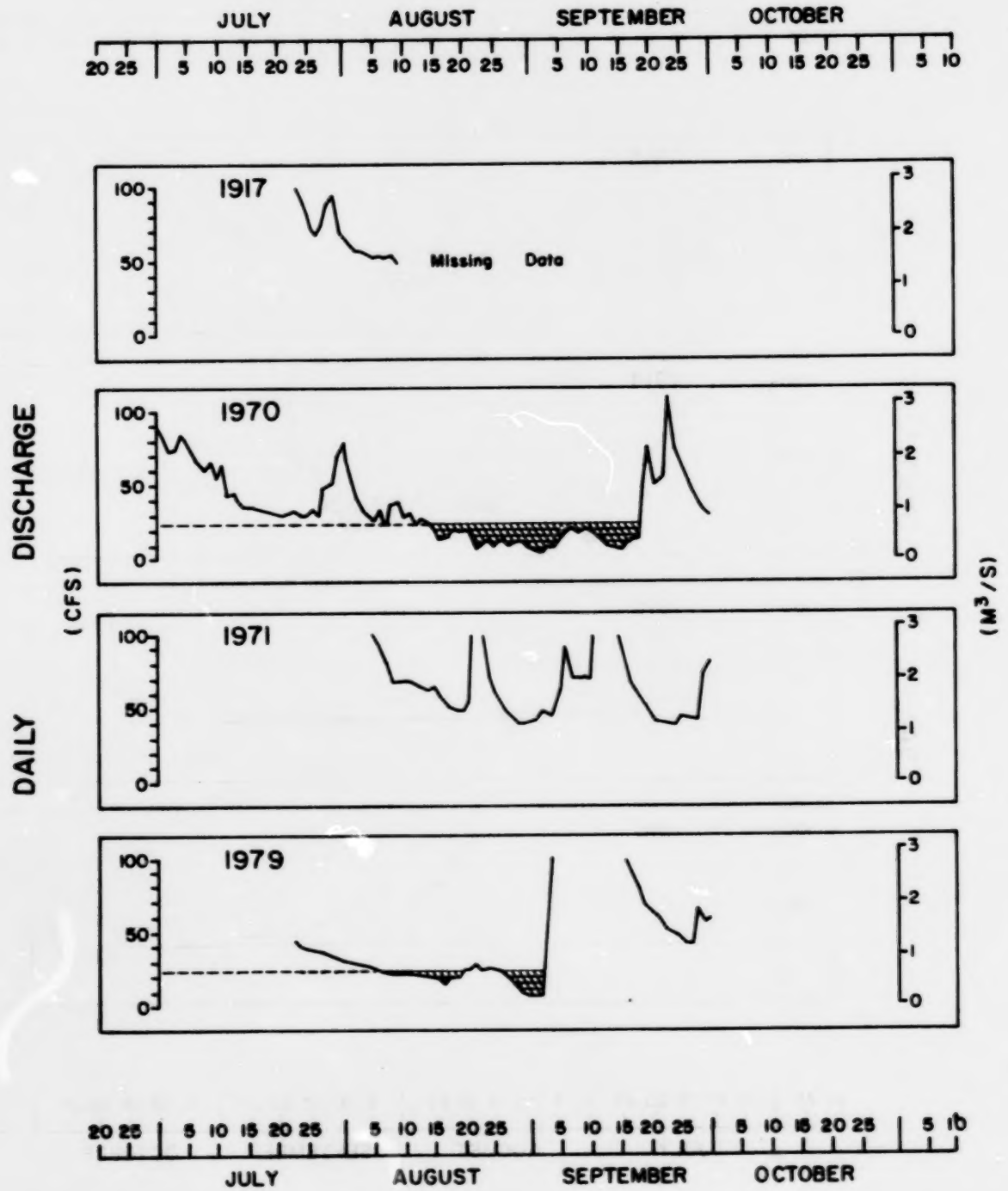


FIGURE 9

ENGLISHMAN RIVER

PARTIAL HYDROGRAPHS



September 20. Figure 10 provides an indication of the probably occurrence of flows below 25 cfs. Prior to August 10 natural flows below 25 cfs are highly unlikely. After the 20th of September, flows much below 25 cfs are also unlikely but in one year (1916) they occurred in late October. On the average, the beginning of September is the most likely time to expect the greatest severity of a flow deficit below 25 cfs. The area under the curve in Figure 10 is the volume of storage that would have been required to maintain a minimum flow of 25 cfs on the average for the years of record. This amounts to approximately 140 cfs days, or 280 ac. ft. During 1914 and 1970, the two most severe years, the storage requirement would have been close to 800 ac. ft.

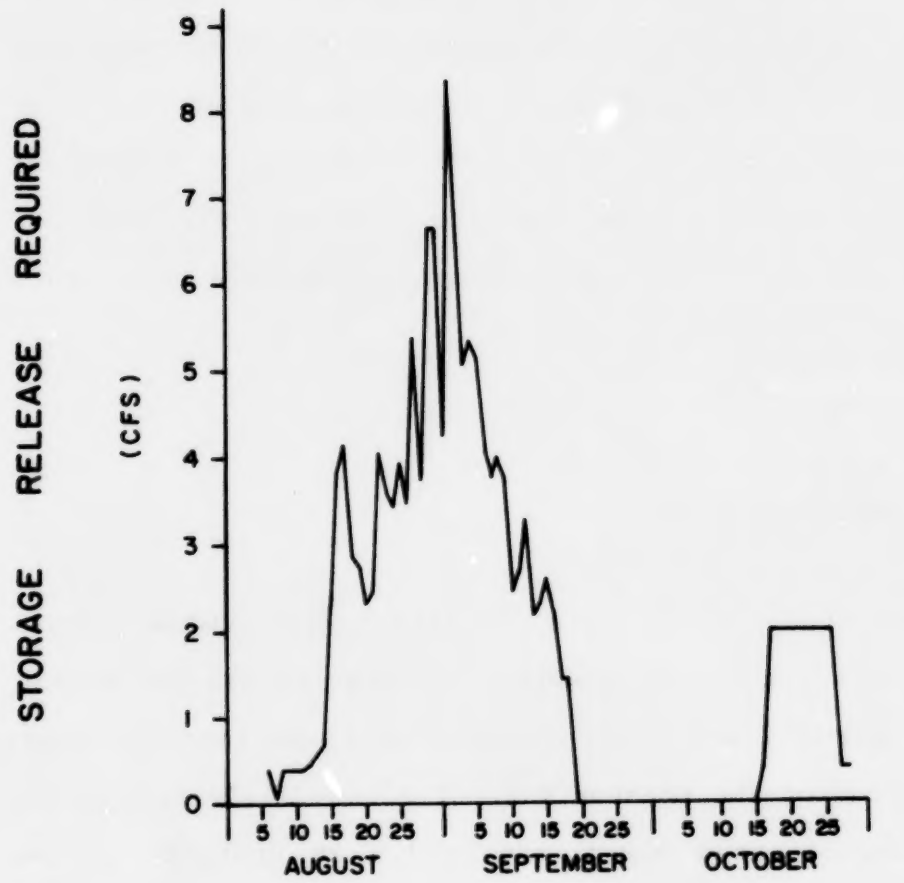
5. SPAWNING STUDIES

Two study sites were selected which were considered to be representative of spawning and rearing habitat in the lower river (Figures 1 and 11). Study site 1 was located immediately downstream of the present Town of Parksville's pumphouse. Study site 2 was located approximately 1.5 km upstream of the pumphouse. Both study sites terminated in downstream riffles. Both provided suitable spawning habitat as well as abundant rearing habitat in low velocity areas along the stream margins.

FIGURE 10

ENGLISHMAN RIVER

STORAGE RELEASE REQUIRED TO MAINTAIN 25 CFS



AVERAGE BASED ON 7 YEARS OF RECORD

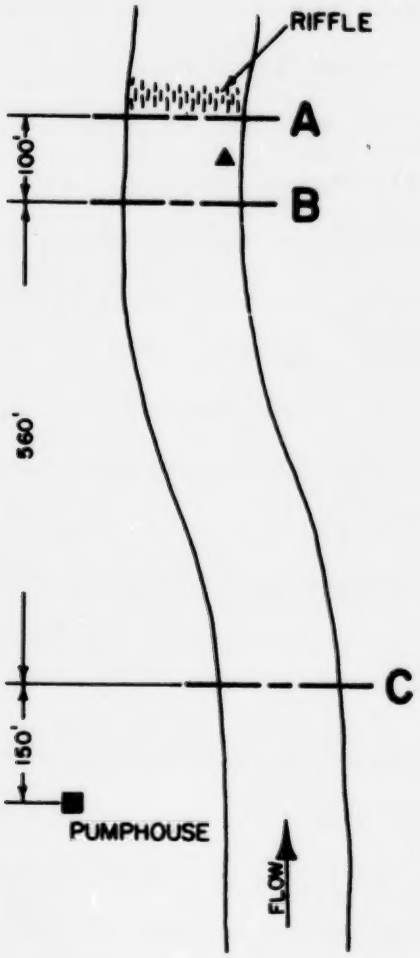
1913 - 16 , 1970 , 71 , 79

FIGURE 11

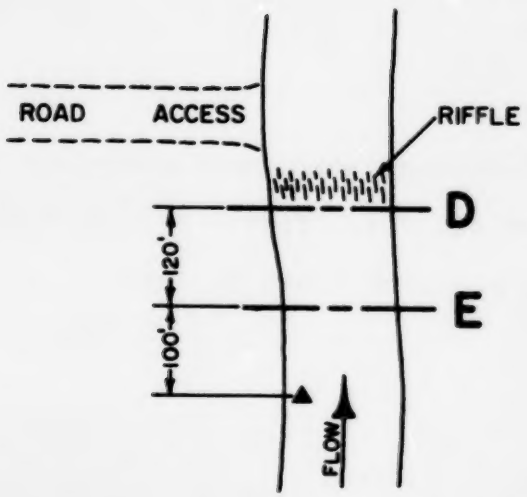
ENGLISHMAN RIVER

SKETCH OF STUDY SITES

SITE 1



SITE 2



KEY

A - TRANSECT

▲ - STAFF GAGE

To determine the effect of stream flow on the extent of spawning habitat, three transects were established at site 1 and two transects at site 2, at right angles to the flow. The flow was metered six times at the five transects during 1979-80. The flows as measured and recorded in table 1 are not equal for each date as might be expected. Flows at transect D, for example, are consistantly higher. This is illustrated in figure 12. Longitudinal flow variations of this nature are not unusual. They indicate an interchange between surface flow and subsurface flow in the river bed, a most desirable phenomenon for spawning areas. During October 1979 heavy chum spawning activity was observed at study site 1, although not at study site 2.

Water depths and velocities were measured at 5 foot intervals along each transect, and substrate size was recorded. Depth, and velocity criteria for chum spawning (after Collings, 1974) were used to calculate useable spawning habitat area at each transect for a range of flows (Figure 13). The optimum flow varies from 200 to 350 cfs depending on the transect, but averages about 275 cfs.

During October, when chum spawning is peaking, the average flow is about 325 cfs. (Figure 7). At flows as low as 25 cfs spawning habitat would be close to zero.

TABLE 1

ENGLISHMAN RIVER
METERED FLOWS (CFS)

	TRANSECT				
	A	B	C	D	E
July 17, 1979	91.5	72.0	75.9	93.1	78.9
August 22, 1979	33.6	27.5	27.5	37.9	28.0
September 24, 1979	66.5	52.8	57.4	72.7	55.2
October 16, 1979	51.2	40.7	38.8	58.8	40.4
November 13, 1979	134.4	120.0	116.7	138.4	113.1
January 7, 1980	444.2	424.8	-	456.6	422.6

ENGLISHMAN RIVER

LONGITUDINAL FLOW VARIATIONS

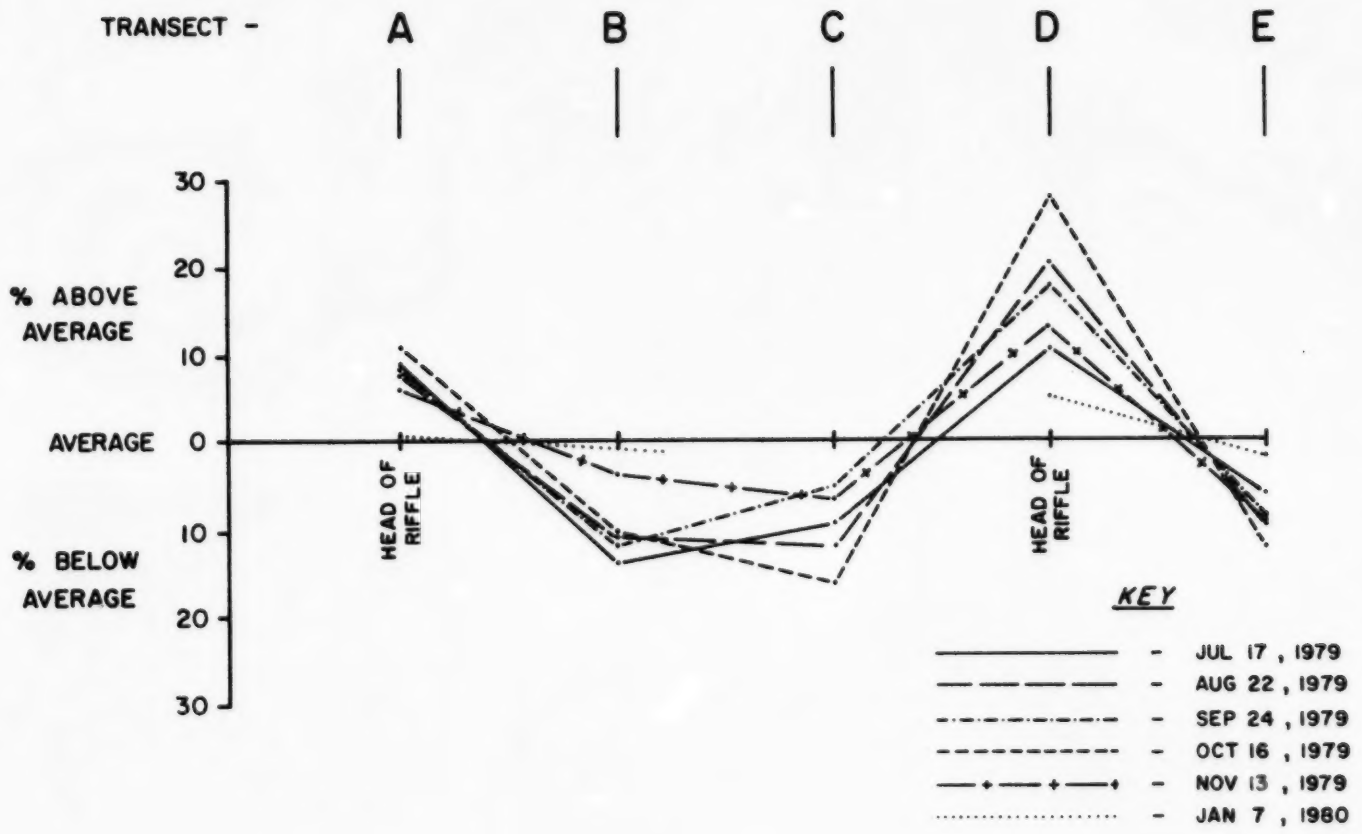


FIGURE 12

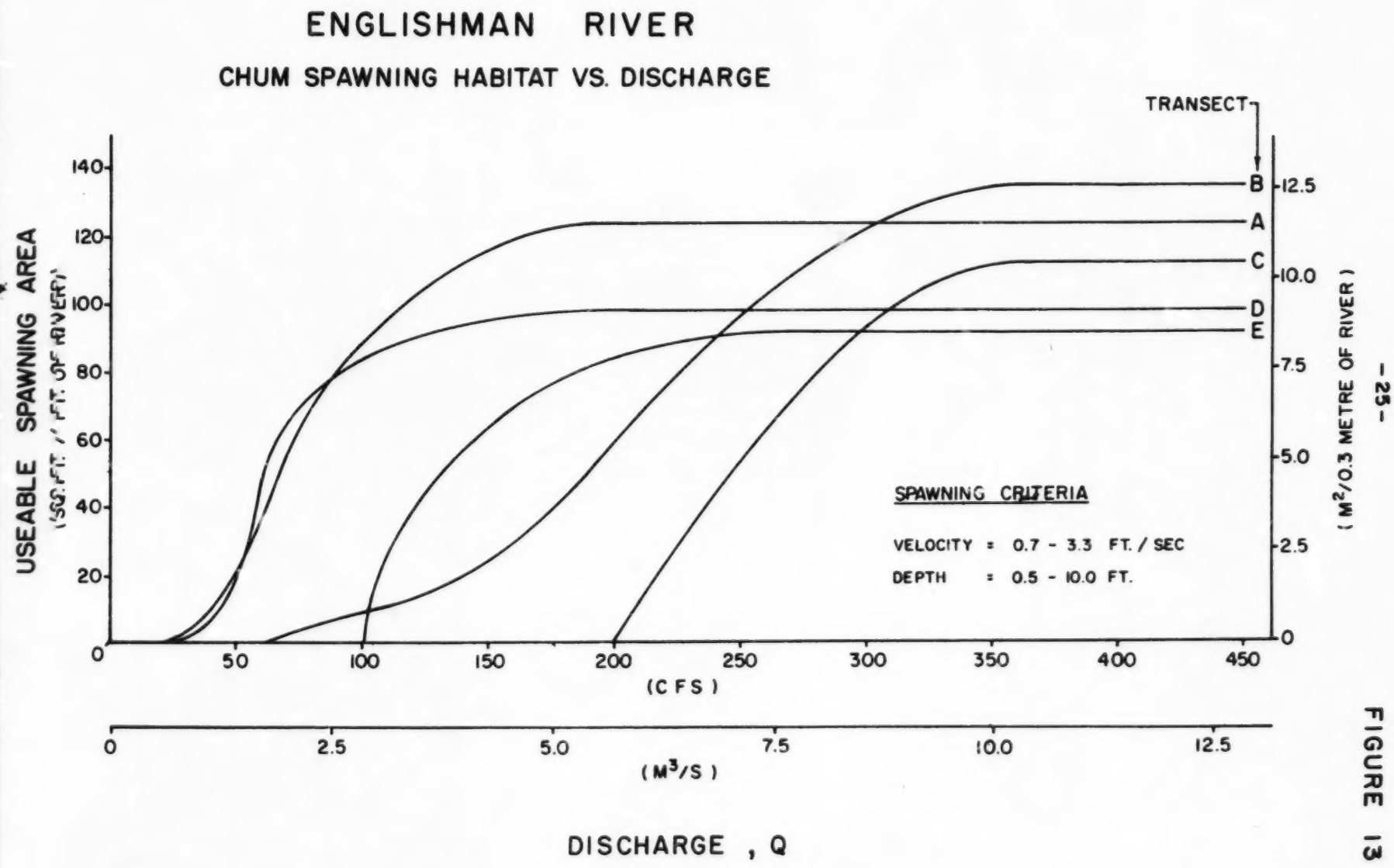

ENGLISHMAN RIVER
CHUM SPAWNING HABITAT VS. DISCHARGE
TRANSECT
B
A
C
D
E
USEABLE SPAWNING AREA
(SQ.FT. / FT. OF RIVER)
(M²/0.3 METRE OF RIVER)
140
120
100
80
60
40
20
0
12.5
10.0
7.5
5.0
2.5
0
SPAWNING CRITERIA
VELOCITY = 0.7 - 3.3 FT. / SEC
DEPTH = 0.5 - 10.0 FT.
50
100
150
200
250
300
350
400
450
(C F S)
0
2.5
5.0
7.5
10.0
12.5
(M³/S)
DISCHARGE , Q

FIGURE 13

6. COHO REARING STUDIES

Coho rearing populations were sampled periodically at several locations in study site 1 using an 8 x 1.5 metre beach seine. Fish were enumerated, fork lengths measured and stomach contents sampled for analysis. In January, 1980, a limited amount of sampling was carried out by electroshocking and trapping with roe-baited "Gee" traps.

Visual surveys of coho fry distribution were carried out at approximately monthly intervals from July to November 1979 at both study sites. Substrate, cover type, depth and velocity were recorded at points where fry were observed, in order to characterize preferred rearing habitat in the lower Englishman River.

6.1 HABITAT CHARACTERISTICS

Observations of coho fry distribution at both study sites indicated a strong association with bank cover in the form of undercuts, submerged roots, peripheral debris, and overhanging vegetation. Coho fry were not normally observed in mid-channel areas, in contrast to trout fry which used the substrate for cover throughout the wetted areas.

Most coho fry utilized pool-type habitat with depths greater than .3 m and velocities less than .21 m/sec. The substrate type appeared to be secondary in importance to cover, depth and velocity in determining distribution. Spot water temperatures as high as 22°C were recorded in July.

6.2 POPULATION ESTIMATES

Sampling data for juvenile coho at study site 1 is summarized in Table 2.

Conservative interpretation of the data presented suggests a high level of utilization of the lower Englishman River by coho fry during late summer and early fall.

On September 25, for example, three locations in study site 1 were seined. Estimated densities of coho fry at these locations varied from 0.70 to 2.68 fry/m^2 (average = 1.62 fry/m^2). These estimates assume 100% sampling efficiency, that is, that all fry present in the area seined were captured. Experience suggests that this assumption is unrealistic and that the values indicated undoubtedly underestimate actual fish densities.

TABLE 2

ENGLISHMAN RIVER
SAMPLING DATA FOR COHO FRY AT STUDY SITE 1

Date 1980	Location	Temp (°C)	Catch	Area Sampled (m^2)	Mean Fork Length (mm)	Mean Weight (g)	Density Fish/m^2
Aug. 22	1	20	16	50	55.5	-	0.62
Sept. 25	2	13	67	25	68.8	-	2.68
Sept. 25	3	-	37	25	-	-	1.48
Sept. 25	4	-	35	50	-	-	0.70
Oct. 17	2	10	16	25	69.4	4.92	1.28
Nov. 13	2	5	0	25	-	-	-

Based on the estimate that approximately 10% of the study site afforded suitable habitat conditions for coho, the total population of the site was estimated to be 1,231 fry. This represents an average density of 0.16 fry/m^2, or expressed as a function of stream length, 6,155 fry/km.

If the overwinter survival rate is 0.3 (Chapman 1965), the expected smolt yield would be 5 smolts/100m^2 or 1,847 smolts/km. According to Marshall (1980), carrying capacity for coho smolts in a large representative coastal stream is 1,894 smolts/km or 24 smolts/100m^2. The estimated production of the lower Englishman River, expressed as smolts per unit length, is comparable to the figure given by Marshall. The estimated smolt yield per unit area, however, is considerably less, because most of the wetted area is not utilized due to lack of cover, rearing coho being largely restricted to the stream margins.

During the November sampling period, seining was not effective and no juvenile coho were captured. However, in January 1980, electroshocking and trapping using roe-baited minnow traps indicated the presence of juvenile coho in side-pools and side channels closely associated with cover such as submerged roots and debris. Utilization of this type of habitat in winter has adaptive value in protecting juvenile fish from displacement by high flows associated with winter storm events.

6.3 STOMACH SAMPLE ANALYSIS

Stomachs were sampled from coho fry on August 22 and on October 17. The results of stomach content analysis are given in Table 3.

Recognizing that sample sizes were small in each case, the data suggests a seasonal shift in the diet of juvenile coho in the Englishman River, from a predominance of aquatic organisms principally chironomids (Diptera), in August, to an increasing importance of terrestrial insects, such as Homoptera and Psocoptera in October. Climatic factors, insect life history patterns, and streamflow, may be involved in varying degrees. For example, aquatic insects may be less available in the drift in the fall because the relatively low streamflows are not conducive to dislodging benthic fauna (Giger, 1973).

6.4 FLOW REQUIREMENTS FOR REARING

For the purpose of estimating minimum rearing flows for the Englishman River, we have used the relationship between surface width and stream discharge. The relationship between wetted perimeter (approximately equivalent to surface width in shallow sections) and discharge has been used in other studies to

TABLE 3

COHO FRY STOMACH CONTENT ANALYSIS

	August 22 n=6		October 17 n=17	
Taxa	Total # of organisms	Frequency in stomachs (%)	Total # of organisms	Frequency in stomachs (%)
Ephemeroptera				
nymphs	12	50		
adults	4	33		
Plecoptera				
nymphs	2	33	3	25
Trichoptera				
larvae			2	13
Diptera				
larvae	117	100	10	38
pupae	7	50	2	13
adults	5	17	3	25
Hemiptera				
adults	1	17	2	25
Homoptera				
adults	1	17	23	100
Coleoptera				
larvae	2	33	4	50
adults	22	67		
Hymenoptera				
adults	2	17	4	38
Psocoptera				
adults	1	17	9	63
Lepidoptera				
larvae			2	25
Thysanoptera				
adults			1	13
Collembola			1	13
Acari	1	17		
Araneida	2	33	1	13
Total	179		67	

estimate salmonid rearing requirements (Collings 1974). As well as reflecting, in a general way, the amount of rearing space available, wetted perimeter is also related to the stream bottom area available for production of fish food organisms. Graphs of wetted perimeter versus discharge typically show rapid increases of wetted perimeter up to approximately the point of maximum curvature[1] beyond which wetted perimeter increases more slowly. The minimum rearing flow is normally set somewhere near this point of maximum curvature.

The relationship between surface width and discharge for each transect on the Englishman River is shown in figure 14. Although the shapes of the curves vary somewhat it is evident that below about 25 cfs the average wetted width begins to decrease rapidly. A discharge of 25 cfs (.71 m^3/sec), then, might be considered to represent a minimum or critical rearing flow for the lower Englishman River.

This flow, however, is not necessarily equivalent to the resource maintenance flow, which is the flow required, on the average, to maintain the present fish production potential of the system. In

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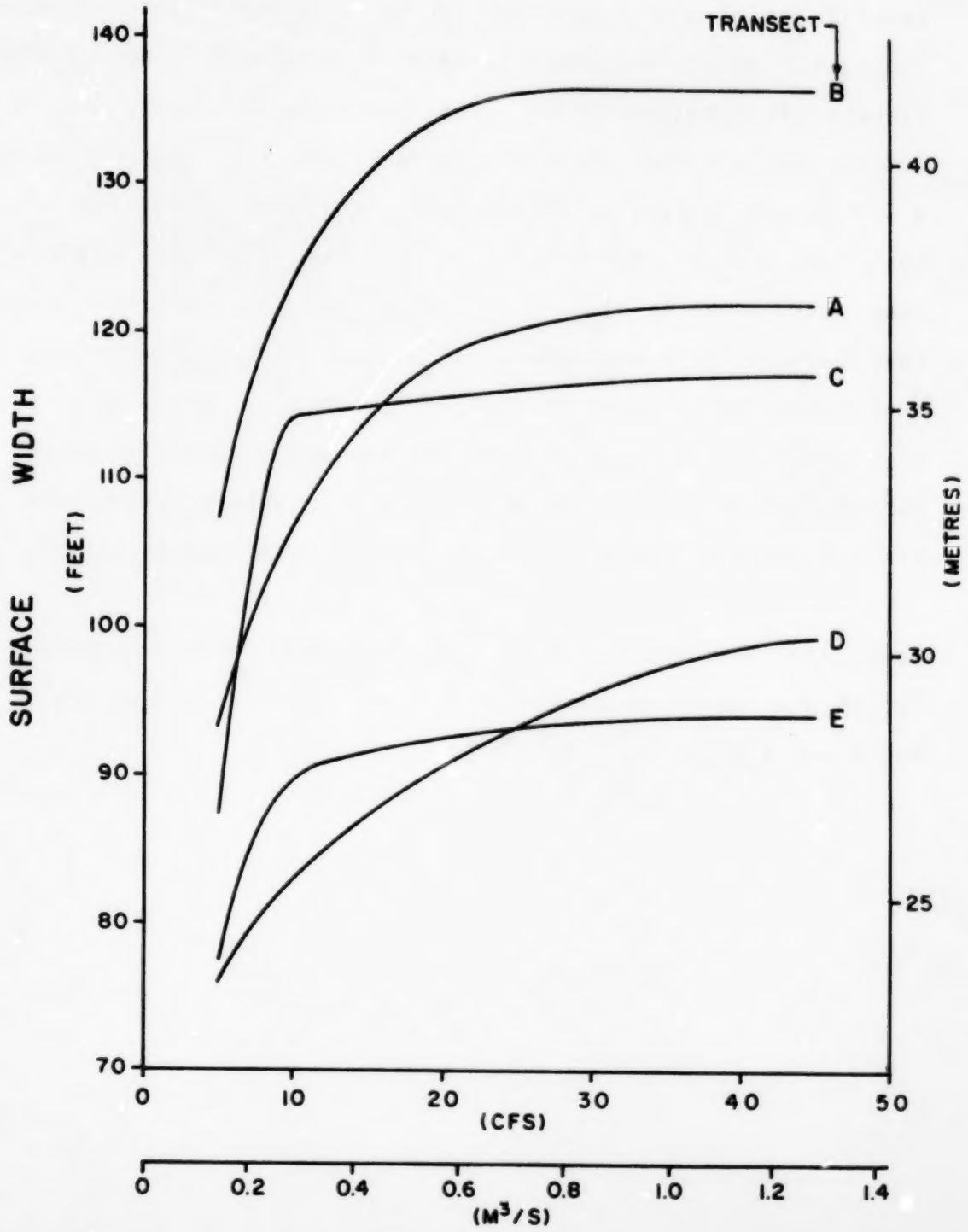
[1]Most of the literature on fisheries flow requirements mistakenly refer to this as the "inflection point".

FIGURE 14

ENGLISHMAN RIVER

SURFACE WIDTH VS. DISCHARGE



the case of coho, low flows during the summer-fall freshwater rearing period are considered to be a primary factor limiting subsequent adult abundance (Neave 1949; McKernan et al.1950; Wickett 1951; Zilges 1974). Any reduction in normal low flows during this critical period, therefore, could be expected to have a detrimental effect on production. Collings (1974) has stated that "the actual or natural limiting discharge for salmon that rear year round in the stream would probably be the discharge that occurs, on the average, 50 percent of the time during the month with lowest flow of the year". This is approximately the mean monthly discharge for the driest month for the period of record, and it is a larger and much more realistic value than the minimum monthly flow on record, which is sometimes suggested.

Using the mean monthly discharge in August over the period of record the resource maintenance flow for the Englishman River would be 44.5 cfs (1.26 m^3/sec).

SUMMARY AND RECOMMENDATIONS

The lower three km. of the Englishman River is the most important area for chum salmon spawning; it is also utilized by coho. A desirable spawning flow for chum and coho from October through December is 200 to 300 cfs. This is normally attained but, occasionally, low flows will occur in October and November. If flows drop as low as 25 cfs spawning habitat becomes virtually zero and upstream migration may not be possible.

The lower part of the river is also heavily utilized throughout the year by rearing coho. Critical flows for rearing generally occur in August and September. The Fisheries Resource Maintenance Flow for rearing is about 40 cfs. Flows less than about 25 cfs result in a rapid decrease of rearing habitat. As low flows tend to be concurrent with hot weather, water temperatures may be a controlling factor in juvenile survival.

The most critical low flow period is usually between August 10 and September 20, when river flows frequently drop below 25 cfs. On the average, 280 ac. ft. of storage would be required to ensure a minimum flow of 25 cfs for this period. In a very dry year, such as 1970, 800 ac. ft. would be required.

The amount of storage required to support a 5 cfs diversion over the same period is 410 ac. ft.

It is evident that storage of 500 ac. ft. (plus losses) should support the diversion; but it would not be enought to support both the diversion and ensure a minimum flow of 25 cfs below the diversion. It is recognized, however, that release of storage during the critical low flow period to support the diversion would improve instream flow above the diversion.

It is recommended that storage be released when the flow immediately downstream of the most downstream diversion drops to 25 cfs. The rate of release should be at least equal to the rate of diversion (plus losses).

There should be provision for some flexibility in the management of the storage so that it is fully used. During times of very low flow or very high temperatures it could be of considerable benefit to fish life to have extra flow released. When low flows persist into the upstream migration and spawning periods it would be desirable to have any residual storage released in a way recommended by us to best ameliorate instream flow conditions, while still ensuring the diversion needs of the licensee.

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APPENDIX A

Englishman River System Biophysical Inventory - June, 1979

Reach	Length (m)	Wetted Width (m)	Pool: Riffle	Bank Cover	Substrate	Comments
1	1,000	-	-	-	50% cobble 30% lg. gravel 15% sm gravel 5% sand (some boulders)	River splits into three channels. Juvenile salmonids observed throughout reaches 1-7 among cobbles, under cut banks and logs, and in pools. Good Rearing potential.
2	400	-	-	-	20% cobble 30% lg. gravel 40% sm. gravel 10% sand	A small side channle abut 60 m long is present in upstream section of reach. Good spawning potential.
3	165	-	-	-	30% cobble 40% lg. gravel 25% sm. gravel 5% sand	Limited spawning area.
4	235	-	-	-	10% cobble 30% lg. gravel 50% sm. gravel 10% sand	Best spawning area in reaches 1-7. Large back channel present approximately 25x75m. Good rearing habitat.
5	500	-	-	-	30% cobble 50% lg. gravel 15% sm. gravel 5% sand	Two small side channels with fair spawning gravel (left bank). Major pool.
6	365	-	-	-	40% cobble 40% lg. gravel 15% sm. gravel 5% sand	Large log jam. Major pool.

cont'd

Reach	Length (m)	Wetted Width (m)	Pool: Riffle	Bank Cover	Substrate	Comments
7	295	-	-	-	40% cobble 40% lg. gravel 10% sm. gravel 10% bedrock	Pools in bedrock
8	145	30	1:1	trace	10% bedrock 40% boulder/cobble 30% lg. gravel 10% sm. gravel 10% sand	Juvenile salmonids numerous
9	230	-	9:1	Mixed Rocky ledges	50% bedrock 10% boulders 20% lg. gravel 10% sm. gravel 10% sand	Good adult holding area. Fre juveniles around
10	310	18	1:9	Mostly decd. contin	70% boulder/cobble 20% lg. gravel 5% sm. gravel 5% sand	T = 13°C. Fry numerous
11	230	24	1:1	inter mitt	20% bedrock 50% boulder/cobble 20% lg. gravel 10% sm. gravel	Series of small holding pools. Fry numerous

cont'd

Reach	Length (m)	Wetted Width (m)	Pool: Riffle	Bank Cover	Substrate	Comments
12	660	28	1:99	Mixed. Conti- nuous hanging vegetation along banks.	75% lg. gravel 10% sm. gravel 5% sand	12°C Caddis larvae abundant. Large numbers of coho fry observed.
13	380	24	10:90	Mixed. Conti- nuous over-hanging vegetation.	65% lg. gravel 25% sm. gravel 10% sand	Coho fry throughout under cut banks.
14	605	27	50:50	Conti- nuous deci- duous overhang.	25% lg. gravel 60% sm. gravel 15% fines	Many fry observed in pool-type habitat mostly along stream banks.
15	190	27	50:50	Mostly conif- erous	40% bedrock 50% sm. gravel 10% fines	Limited habitat.
16	335	31	60:40	Mostly deci- duous canopy	30% lg. gravel 60% sm. gravel 10% fines some bedrock	Large pool above highway bridge. Fry numerous throughout wetted area. Good benthic production.

cont'd

Reach	Length (m)	Wetted Width (m)	Pool: Riffle	Bank Cover	Substrate	Comments
17	1,185	36	70:30	Mixed	25% lg. gravel 60% sm. gravel 15% fines	Fry numerous along banks uver overhanging vegetation.
18	475	-		Mixed Continuous	20% lg. gravel 60% med. gravel 15% sm. gravel 5% fines	Good chum spawning area. Fry in small pools. Rip-rap on left bank.
19	-	-		Intermittent deciduous	95% sand 5% gravel	Marine influence at high tide.
S. Englishman River	4.5km accessible to anadromous species	3	Mostly Riffle	Mixed continuous	Mostly med-large gravel and bedrock.	Coho fry observed up to falls.
G. Tributary	-	3.5	Mostly riffle	Mixed continuous	Mostly med-large gravel	Coho fry in lower reaches.
Morison	-	-		Deciduous continuous	30% bedrock 50% cobble 20% fines	Coho and trout fry numerous